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WEATHER AND CROPS.

Although the month of May was rather cooler than usual, temperatures throughout the Group, with the approach of the summer season, averaged nearly two degrees higher than during April. At Honolulu, the mean daily departure from the normal temperature for May (average of two stations) was 1.3 degrees. High barometer and northeasterly winds prevailed except during the last week of the month, which was marked by a decided decrease in atmospheric pressure and a temporary suspension of the trades.

The rainfall for the month was slightly above the normal in the southern and central portions of the Group, but somewhat below the normal in the northern portion. In windward districts, the moisture was quite well distributed throughout the month. The severe drought in the Kau district of Hawaii was effectually broken by heavy showers during the last week.

Conditions throughout the month were quite favorable for the growth of cane, although high winds during the first and third weeks caused some slight damage to the leaves. The harvesting and grinding of mature cane continued rapidly, the work being completed for the present season on a few of the plantations by the close of the month. The preparation of land and planting for the 1907 cane crop also proceeded as rapidly as possible in all sections. An excessive amount of moisture interfered somewhat with field operations in the Hilo district of Hawaii during the first few days of the month. The growth of the summer crop of pineapples in Maui was slightly retarded during the first half of the month by cloudy and showery weather, and in central Oahu by the cool, dry nights; but, as a whole, the weather conditions were generally favorable, and by the end of the month some early fruit had begun to mature; a fine crop is expected.

CHEMICAL CONTROL IN CANE SUGAR FACTORIES.

By H. & L. Pellet.

The February number of the "Bulletin de l' Association des Chimistes de Sucreries et Distilleries" contains a very interesting article on the chemical control in cane sugar factories, giving the methods of analysis adopted by the Hawaiian Sugar Chemists' Association.

While certain determinations are very much simplified, others, on the contrary are very complicated.

It is not the object of this paper to indicate the methods, which should be employed. We propose to do this in a special article, as the subject is of great interest from many points of view. For the present we will restrict ourselves to some comments on the methods adopted in the Hawaiian Islands.

The calculation of the sucrose in the cane is based on the percentage of fiber. This latter being known, the difference between 100 and the fiber is taken to represent the juice. This, with the percentage of sucrose in the juice gives the percentage of sucrose in the cane.

This method is very simple, too simple, but it does not appear to us to be accurate inasmuch as we cannot know the true sugar content of the cane. This latter changes with the degree of pressure to which the cane is subjected, in the Hawaiian Islands as much as anywhere else. Below are some figures taken from the magnificent work on the sugar industry in Hawaii and Reunion:

	Hawaii	Cheribon-cane.	
	1	2	3
Purity of 1st Mill-juice	88.4	88.0	89.5
Purity of 2nd Mill-juice............	83.7	....	83.6
Purity of 3rd Mill-juice............	....	85.3	80.0

This goes to show, that the juice remaining in the bagasse is still more impure than the juice resulting from the last crushing.

It is therefore evident that we cannot arrive at the true percentage of sucrose in the cane by multiplying the percentage of sucrose in the juice by the co-efficient 100 fiber.

This fact has been proved and is universally acknowledged; but which is the correct co-efficient? For instance, if the fiber be 10%, leaving 90% of juice, will this co-efficient be .88 or .87 or .86. This must be determined by numerous practical experiments.

On the other hand we do not believe, that this co-efficient can fall below .85, or on rare occasions perhaps .84, and that it can reach .77 or .79 as in certain factories in Java, according to a table given by Prinsen-Geerligs.

For the determination of fiber a very complicated method is used, while the operation is so simple, if done with Zamaron's apparatus; the determination of sucrose in bagasse on the other hand appears to us to be too much simplified.

From a large number of tests made we have come to the conclusion that simply boiling with water does not extract all the sugar from the bagasse. This depends upon the division of the bagasse as well as upon the nature of the cellular tissue of the cane. I is, nevertheless, possible, that owing to some peculiarity of Hawaiian canes the digestion with water yields accurate results, but this should be constantly verified; we prefer the use of Zamaron's apparatus with the successive extraction process. Besides by this process the determination of sucrose and fiber in the bagasse are done in the same operation. It is therefore both very simple and very accurate; it is applicable to all varieties of cane and consequently to all bagasses, whatever the quality of the grinding, or the fineness of the bagasse sample may be.

Furthermore, if the sucrose in cane is calculated without determining the true co-efficient according to the Hawaiian method or at least the most accurate possible, the value for the sucrose will be found too high, as also—quite naturally—the undetermined loss.

On the other hand, if the indirect method as generally followed in Java be used, i. e., Sucrose in Cane=Sucrose in Juice +Sucrose in Bagasse, the Sucrose content of the cane will be found too low, the undetermined losses will not be the same as they would were too high a co-efficient to be used; but the rendement appears better according to the richness of the cane.

In many cases it is therefore preferable to compare the sugar obtained including the sugar in molasses and the sugar lost with the sugar in the juice. The quantity of the latter is generally known in practice.

It remains for us to examine the methods given in that pamphlet for the calculation of the extraction. This will form the subject of a special paper. Suffice it for the present to say, that the method used for the determination of the dry matter in the molasses appears to us much more complicated and subject to errors than the one which consists in drying the substance in our special capsules and in presence of pumice stone.

(Bull. de l' Ass. des Chin. de Sucr. et Dist.)

The writer dwells at great length on the fact that the juice in the cane is not homogeneous and criticises the H. S. C. A.'s methods on these grounds. Evidently his knowledge of these methods is only partial, as the difference in the quality of the juices resulting from the different successive pressings is fully taken into account.

The methods do not provide for a co-efficient, which multiplied with the percentage of sucrose in first mill-juice, gives the percentage of sucrose in the cane.

The writer asks: Which is the correct co-efficient? He can find it by dividing the percentage of sucrose in the first mill-juice by the percentage of sucrose in the cane, as found according to the mode of calculation given by the H. S. C. A. For some reason or other the writer doubts, that this co-efficient can fall below .85 or .84. While with clean cane of the Lahaina or Bamboo variety this co-efficient will be found to be somewhere between .85 and .87, it can with the Yellow Caledonia, a variety containing in normal mature condition from 13 to 16 per cent. of fiber be found as low as .81 or .82. H.

IRRIGATION IN HAWAII.

By Walter Maxwell, Ph. D.

(Continued from page 196.)

DISTRIBUTION OF WATER.

In the Hawaiian Islands sugar cane is irrigated exclusively by means of ditches and furrows. In laying out a field to be planted in sugar cane the first step is to make a survey of the area and to determine its contour. The notes of the survey will show the direction in which the cane furrows shall be constructed and also show where the laterals which feed the furrows should be located. On uneven ground the furrows are curved in order that the grade may be kept uniform.

If a field is practically level—and there are vast areas of relatively level land in location where cane sugar is likely to be grown—the furrows are dug straight through the field. The most level field, however, usually has a dominant decline in some direction which is usually determined by the general formation of the lands of the region. The Hawaiian Islands are of volcanic origin, and hence the general slope of the land is from the craters to the sea. The country is mountainous in the neighborhood of the volcanoes. The slopes become flatter as lower levels are reached, until the decline apparently disappears in the lands bordering on the seacoast. The latter have been deposited by streams running from higher lands. In spite of the flat appearance of these lowlands they generally have a decline toward the sea which is not only sufficient to make the distribution of water a simple matter, but also to effect the discharge of underground water. This, however, is not always the case, the writer having several tracts in mind where the ground water can not find a discharge owing to its surface being but slightly above the level of high tide.

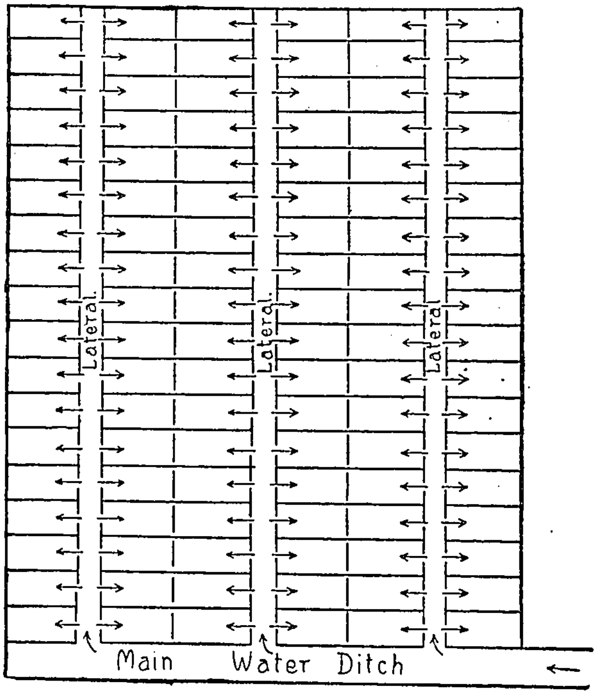


FIG. 2.—Irrigation of sugar cane on level land by means of laterals.

The diagram (fig. 3) shows a field that is furrowed for planting and has subditches dug for the distribution of water. The furrows are made at right angles to the fall of the land and the distributing laterals are constructed at right angles to the furrows, or parallel with the natural water flow.

As the diagram shows, the main ditch feeds the laterals and these feed the furrows. The laterals discharge into the furrows on each side, the water flowing one-half of the distance between laterals in each direction. The furrows in the diagram are between the rows of cane. In the Hawaiian Islands the cane is generally planted and kept in furrows and not ridged up, and the water is applied in those furrows, running in and out around the cane stalks. In other countries visited by the writer, where irrigation is required during a part of the growing season, the cane is more generally upon the ridge and the water is applied between the rows of the cane, as shown by the diagram. The practice is controlled by such factors as the nature of the soil, the rainfall at specific seasons, and the related questions of drainage.

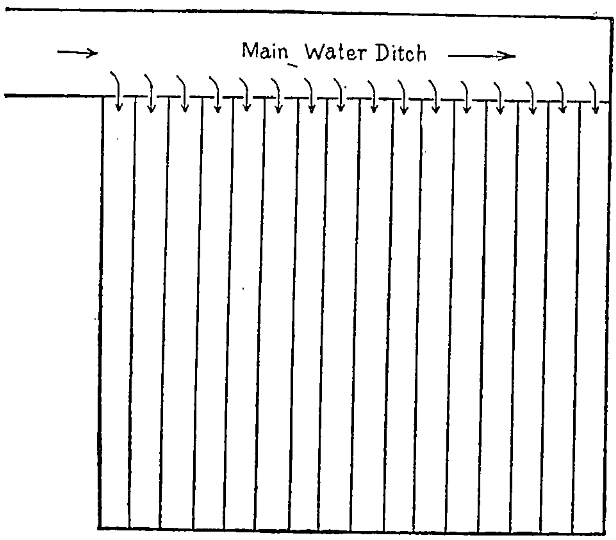


FIG. 3.—Irrigation of sugar cane on level land by direct discharge of the water from the main ditch into the furrows.

In the diagram (fig. 2), the lines indicating the rows of cane are assumed to be 5 feet apart, which is the usual distance. In some situations, owing to local causes, the distance between the cane rows may be as much as 6 feet or as little as 4½ feet. The distance between the laterals is assumed to be 30 feet, which means that the water is intended to flow only 15 feet from each side of the laterals that are feeding the furrows. The lines running midway between but parallel with the laterals represent earth dams in the furrows. These limit the length of flow of the water from the laterals on each side. Only lands having a very even surface can be laid out upon the simple plan of the diagram.

Before speaking in detail of the methods of applying water, one other system will be described. This provides for the direct discharge of the water from the main ditch into the furrows. The system (fig. 3) has been observed by the writer, its results considered, and it is mentioned chiefly to show its essential defects.

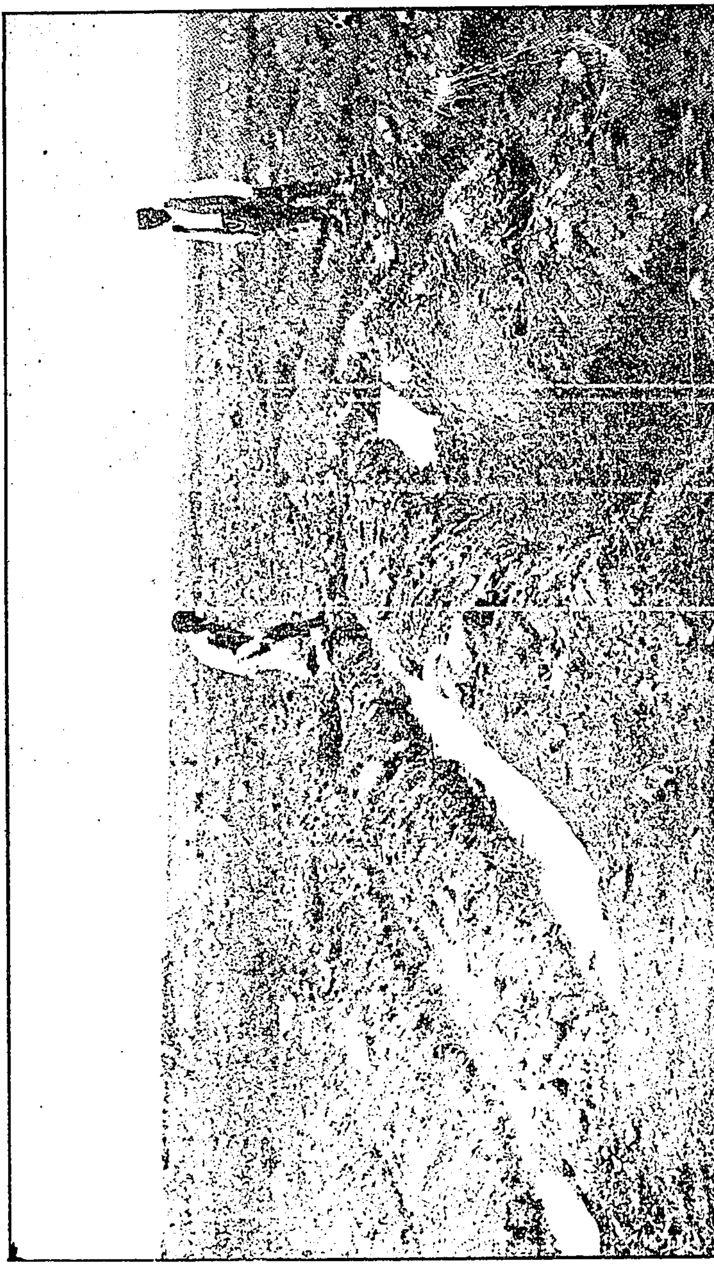
In the system illustrated in this diagram (fig. 3), the water supply is from a main ditch of considerable size (a width of 5 to 8 feet has been observed), which feeds the water furrows between the rows of cane direct, as illustrated by the arrows in the diagram. The cane rows are drawn straight through the field. The water flows parallel with the rows of cane and not at right angles to them, as shown in diagram (fig. 2.) Consequently the water has to distribute itself by flowing from the main ditch to the opposite end of the field. As already remarked, this system of distribution is exemplified in order to make clear its very palpable drawbacks, which will be briefly explained.

Volume of the application.—Schuyler and Allardt, in treating of this subject under the conditions of the Hawaiian Islands, state that "it seems to be generally understood by all planters that the depth of each watering, i. e., the volume of each application, shall be at the least an average of 3 to 4 inches over the whole surface of the ground." The same authors quote one of their witnesses as saying "11,000 cubic feet per acre every seven days will produce the very best results in growing sugar cane." That volume is equal to 3⅓ inches of water over the whole ground per weekly application. Another example from the same authority gives "10,890 cubic feet per acre to each watering every seven days." This volume is equal to an application of 3 inches of water over the whole ground once a week. When the small rainfall was added to the amounts applied by irrigation upon the plantations spoken of by Schuyler and Allardt, then the average application per seven days over the stated period of fifteen months or sixty-five weeks appeared as follows:

Depth of water applied to sugar cane during sixty-five weeks (rainfall and irrigation).

Plantation.	Water applied per acre. Inches.	Mean application per week. Inches.
Sprecklesville (1)	262.0	4.03
Sprecklesville (2)	216.0	3.32
Hamakuapoko	230.2	3.54
Kekaha	198.2	3.05

The figures in the outer column indicate the average depth of application per week during the growth of the crop, which is given as sixty-five weeks. Concerning the value placed



upon the rainfall, Schuyler and Allardt say, "the rain may at times exceed the quantity applied artificially, but irrigation is performed the same as usual, notwithstanding, in order that there shall be no break in the continuity of the waterings."

Mode of application.—The two chief systems of applying irrigation water have already been spoken of: First, by flooding, and second, by furrow application (Pl. V.) Two methods of applying water by the system of furrows have also been considered and illustrated (figs. 2 and 3). For the present purpose we return to the method exemplified by fig. 2, or the system of a main ditch which feeds the laterals which in turn feed the furrows, the furrows being laid out at right angles to the laterals, which are drawn parallel with the natural slope of the land or with the water flow. As represented by fig. 2, the section of furrow between the laterals is assumed to be 30 feet in length, each lateral watering 15 feet on either side. This illustration is intended to exhibit an example of water distribution in the furrow that is highly efficient from the standpoint of utilization of the water. Upon many plantations, however, the method of feeding the furrows from both sides of the laterals is not in practice. Very frequently the water is let into the furrows from only one side of the laterals, although this practice is giving way. Again, the length of the section of furrow along which the water has to flow, in present practice, varies from 30 to 50 feet, sections 35 to 45 feet being the more common.

The length of time that a given flow of water will require to reach the end of a furrow section, all other things being the same, will be in proportion to the length of the section; consequently, the length of time that the water must flow over the end of the section of furrow abutting the feeding lateral is decided by the time that the water requires to reach the farther end of the furrow. The other factors also controlling the length of time required to reach the whole length of the furrow are the volume of the stream, the slope of the ground, and porousness of the soil. When the soil is loose, as it is in furrows newly made, the water travels slowly, it being absorbed by the soil at the end of the furrow next to the inlet. The continued flow finally saturates the soil, and the water gradually travels along the furrow until it reaches the farther end, when, after a short time, it is shut off and turned into the next furrow. As the soil in the furrow becomes more solid and close with time the water travels more quickly, and the distribution tends to become somewhat more even, but in such a length of furrow the distribution never becomes uniform. The economic results of this uneven distribution are immediate, and as follows: The effect of an excess of water at the end of the furrow next to the inlet upon the cane is first to retard the germination of the seed by largely excluding the air from the soil, without which incipient growth can not proceed. The effect upon the cane continues and has been observed even up to its maturity. The action upon the soil is first seen in the washing out of the soluble constituents upon which the crop depends for its nutrition. If the action is continued in lowlands where there is imperfect drainage, the mechanical state of the subsoil is seriously affected, becoming close and more impervious, which is due not only to the water but also to the carrying down of soluble alkaline salts. While these effects are taking place at the end of the furrow which receives the great excess of water, the 15 feet at the farther end is not receiving moisture enough for the requirements of the cane; the cane there is suffering for want of water, and the 15 feet next to the inlet is suffering from an excess of water. The midldle 15 feet in the section is the only portion which is receiving approximately an average of the quantity that is being applied. Were the sections of furrows only 15 feet long, with laterals feeding the furrows on each side, the distribution of the water would be relatively even over the whole surface of the ground.

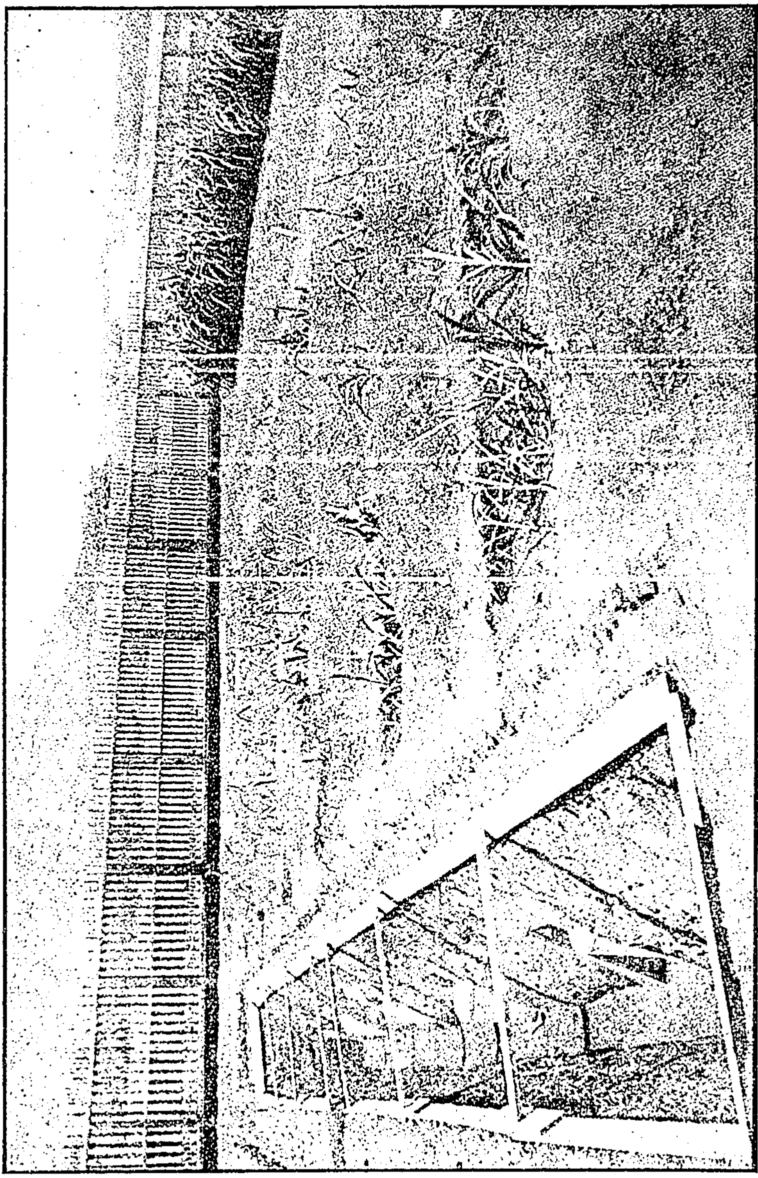
At the Hawaiian Experiment Station the land is relatively level. The furrows are parallel and are 5 feet apart. They are also divided into sections 10 feet in length for irrigation. At the first irrigation and afterwards, until the cane becomes too large for their use, the sections are divided by iron gates that are made to fit and block the furrow. Later, permanent divisions of earth are made. Each section of 10 feet receives by actual measurement, its quota of water, the number of gallons applied meaning either half an inch, 1 inch, or whatever is determined upon. By this system the ground receives uniformly the same depth of water.

Returning briefly to diagram (fig. 2, p. —), it can now be better indicated what the results are when this system is adopted. As will be remembered, the water is supplied directly by a main ditch. From it each furrow is fed, the water being let in and the flow continued until it reaches the farther end of the field, which in some cases is from 400 to 600 yards distant. After the remarks already made upon the impossibility of an even distribution of water by furrows that are only 35 to 50 feet long, it is not necessary to consider in detail the results of pouring water into furrows until it traverses a length of 500 yards. If the soil is porous, one-half of the field is soaked to ruin, while the farther half receives only half the water it could use. If the subsoil is close and imprevious and the volume of water applied is near the average needed for uniform irrigation of the cane, the excess travels to the farther end of the field, where it stands and becomes stagnant.

Frequency and volume of application.—The volume of water to be applied and the frequency of the application are controlled by the crops being grown and the system of irrigation in use. The volume of water applied and the manner of applying it are factors which in one respect control the frequency of the application. If the sections of the furrows exceed a given length, say 15 feet, it will be impossible to apply a small volume, since the water would not reach the farther end of the furrow. If, however, we adopt a length of furrow not exceeding fifteen feet, we then make it possible to lessen the volume of the application and yet secure good results by a more frequent application of the reduced volume.

In considering the question of the volume of water that can be applied without loss, we are led back to a former paragraph where data are given upon the relative power of soils to absorb and retain moisture. These physical properties, however, are not the only factors which determine the volume of water that an acre of land can hold and the volume of water that may be applied. The mass or depth of the soil is a still more significant factor. Deep soils, such as exist on these islands, where the depth may be 5 or more feet, can take up a large volume of water. Of course, if a large volume is repeated often enough and at short intervals, even such a soil will become saturated, and then the water will escape and be wasted. There are soils, however, and over considerable areas of the Hawaiian Islands, which are relatively very thin, the depth varying from, say, 8 to 15 inches. It is at once apparent that such soils, even if their absorptive power is up to the average, can not take up the same volume of water as the deeper soils spoken of, so that the escape and waste of water from them is not only great but much more rapid. Moreover, when a shallow soil, we will say of 12 inches over the level, is furrowel out for planting and irrigation, the depth of soil remaining at the bottoms of the furrows is reduced to about 6 inches. When the water is run into the bottom of the furrow it has merely 6 inches of soil to absorb it and prevent its escape. The soil of the ridges between the furrows, of course, could take care of the water if the latter were being spread over the surface of the whole ground, which is the case under natural rainfall. It has been observed, however, that the lateral absorption of the water by the ridges is relatively small compared with the vertical rate of absorption of the soil in the furrow bottom, to which force has to be added the action of gravity in drawing the water down.

The volume of water that can be applied by irrigation with-



out loss in Hawaiian soils has not been even approximately ascertained. In 1897 certain tests were made at the Hawaiian Experiment Station in order to obtain some light on this question. These tests were carried out by means of a lysimeter devised by the writer (Pl. VI), which may be briefly described as follows: The lysimeter consists of drains 44 inches deep with galvanized-iron gutters which discharge into a deep trench. At the end of each drain is a receiver that catches any water which is in excess of what the soil can hold, and which consequently passes out through the drains. The soil that was removed for laying in the drains was put back and the drains were completed six months before the cane was to be planted, in order to restore the soil to its normal state. Six such drains were made as described, and cane was planted upon five of these, the drains being 8 feet apart and 20 feet long. The nature of the soil has been stated by the analysis in an early paragraph, and the depth is 15 inches, resting upon a porous and rather general subsoil. The depth of the drains was made 44 inches, by which it is seen that some 30 inches of subsoil were cut through. Any water escaping through the soil and through the noncapillary subsoil to that depth it was safely assumed would be finally lost.

When the cane was planted an equal quantity of water, but merely enough to start and keep the cane growing, was applied to each drain or row, this being continued until the cane was 1 foot high, when the actual tests began.

The applications of water to five of the six drains were as follows, drain No. 1 being omitted:

No. 2. Volume equal to one-half inch per week over the whole ground; application made every seven days.

No. 3. Volume equal to 1 inch per week over the whole ground; application made every seven days.

No. 4. Volume same as in No. 3; application 1.5 inches every ten days.

No. 5. Volume same as in No. 4; application 2 inches every fourteen days.

No. 6. Volume and application same as in No. 5.

In No. 6 no cane was planted.

The tests covered twelve weeks, and the results from the drains were as follows:

Water applied to drains, and the quantity lost.

No. of drain.	Total water applied. Gallons.	Amount and frequency of application.	Total loss from drains Gallons.
No. 2	408	½ inch per 7 days	0
No. 3	816	1 inch per 7 days	0
No. 4	816	1½ inches per 10 days	32.3
No. 5	816	2 inches per 14 days	131.3
No. 6	816	do	272.3

Drain No. 6 was a check, by which is meant that while it was constructed precisely as the other drains no cane was planted upon it, in order to show by comparison the actual work of the cane in preventing the loss of water. As the table shows, Nos. 5 and 6 were watered exactly the same. They received an application every fourteen days and a volume equal to 2 inches over the whole ground. No. 6 drain discharged 272.3 gallons, while No. 5 lost only 131.3 gallons, the difference of 141 gallons being due to the retaining action of the growing cane. Bearing upon this matter of the water-holding action of the cane, it may be stated that drain No. 4, which received 1.5 inches of water every ten days, lost the whole 32.3 gallons of the first and second applications when the cane was still very young. After that period the more-developed cane took care of all the water applied, none being lost. The same action was observed with drain No. 5, which also lost the most of the 131.3 gallons by drainage during the first three or four applications. These demonstrations of the increasing consumption of water by the crop with its increase of growth are in line with the determinations made with the cane growth in the tub.

The results of the lysimeter tests are most valuable and to a degree very conclusive, but an objection may be raised to their complete conclusiveness, due to the circumstance that the conditions were not those of normal, undrained land. The digging of the drains and the putting back of the soil disturbed the natural state of the soil, rendering its condition different possibly from the field as a whole. In view of such possible objections to the results from the lysimeter, two more series of tests were begun, which are not yet fully concluded. The first series was conducted with plats of land one-twentieth of an acre in size, along which three rows of cane were planted. In these there was no disturbance of the soil whatever, no drains being made. At the end of the plats and opposite the middle cane row on each plat an observation hole was dug to a depth of 50 inches. From this hole an iron pipe was driven in a length of 7 feet, 3 feet of the pipe reaching along under the cane row at the said depth of 50 inches. This arrangement was made in order to note the results of applying at regular intervals different volumes of water. The results were as follows:

Water applied to cane crops, and the quantity lost.

Plat.	Depth application per week. Inches.	Volume applied per acre per week. Gallons.	Water lost.
No. 1	1	27,154	None
No. 2	2	54,308	Considerable
No. 3	3	81,462	Enormous

It was not possible to determine directly the actual loss of water that took place, due to the fact that it sank down into the subsoil over a wide area and did not converge to any point of outlet. The pipes that were driven in discharged some water, but only a small proportion of what was being lost. This was proven by tunnneling in to a depth of 1 foot under the pipes, a hole being made some 8 feet long and large enough for a man to creep up. After each irrigation water was found running down into the subsoil and draining out to lower levels. As a considerable discharge was taking place where 2 inches per week were being applied, even when the cane was 6 feet high, an idea is conveyed of the enormous waste that followed the application of 3 inches per week.

The second of this series of tests is still being carried on upon 3 plats of land near by the location of the first series. In this second series the plan was made the same as in the the tests with the lysimeter, a given volume of water being applied to each of the three plats, but with different intervals of time between the applications, as follows:

Water applied to cane in second test.

Plat.	Depth of application.	Volume applied per acre.
No. 22	1 inch per 7 days	27,154 every 7 days
No. 24	2 inches per 14 days	54,308 every 14 days
No. 26	3 inches per 21 days	81,462 every 21 days

These tests are being made under such conditions as prevail on a large scale upon plantations. In plat 22, which receives its water in weekly applications, the cane seed germinated three days earlier than where the heavier applications were made. On plat 26 the cane came up, not only slowly, but unevenly and with a yellow, sickly color. From the first and up to the time when the cane was nine months old the results of the weekly application were highly satisfactory. As was shown in the first of this series of tests, where a large application of water is made at one time the soil can not contain the whole of it, and a large portion drains into the subsoil and is lost.

A very clear distinction has to be made between a rainfall of 3 inches in depth, which falls during several hours and uniformly over the whole surface of the ground, and an irrigation equal to 3 inches in depth over the whole ground, which is not only applied in bulk within a few minutes, but the application of which is in a furrow comprising less than one-half of the total surface. In the latter case the physical property of the soil—i. e., its absorbent power—has comparatively no time to act and take up the water which is drawn down from the furrow bottom by gravity and out of reach of the cane roots. On the other hand, the rain is distributed equally over the whole ground surface and ordinarily falls at such a rate that the soil particles can take up and hold it. Rainfall, of course, when the ground becomes saturated, behaves like irrigation water, and the excess seeps out below and runs away. In illustration of the different ways in which rainfall water and irrigation water behave, by reason of the different modes of application, and of the phenomena which control these different behaviors, we give some data in detail from our experiment station records (lysimeter tests):

Comparative loss of water received from irrigation and from rainfall, drain No. 5.

Date.	Depth and source of water received. Inches.	Gallons.	Height of cane. Feet.	Lost from drain. Gallons.
October 28	2, irrigation	136	1	20.50
October 27	2½, rainfall	158	1¼	86.50
October 12	2, irrigation	136	3¼	27.50
September 19	do	136	5	18.59
September 15	½, rainfall	34	5	8.25

Before discussing the data in the above table I shall give another table made up of the data attaching to No. 6 drain of the lysimeter:

Comparative loss of water received from irrigation and from rainfall, drain No. 6.

Date.	Depth and source of water received. Inches.	Gallons.	Lost from drain. Gallons
September 15	2, irrigation	136	25.5
September 19	2½, rainfall	158	91.5
October 12	2, irrigation	136	44.5
October 27	do	136	36.5
October 28	½, rainfall	34	1.0

If we compare the behaviors of drains Nos. 5 and 6 on the dates September 15 and 19, it is seen that No. 5 drain discharged considerably less water than No. 6. At that period there was enough of a root system developed in the cane to enable it to consume the water and to prevent its loss as compared with drain No. 6, where no cane was planted. On October 12 the water consumed by the cane, which was notably larger, was evidently still greater, since No. 5 drain let only 27.5 gallons of water run out, against 44.5 galllons discharged by No. 6. On October 27 the water lost by No. 5 drain is just one-half of the volume given out by No. 6, while on September

15 No. 5 held back only one-fifth more water than No. 6, which was due to the small size of the cane on No. 5 at the earlier date. The next day, October 28, one-half inch of rain fell. Of course the soils of both drains Nos. 5 and 6 were almost at the point of saturation. But it is seen what occurred: No. 5 lost 8 gallons out of the 34 gallons received, while No. 6 drain discharged merely 1 gallon. The result is reversed as compared with what took place on the dates September 15 and 19. In the first place we see the action of even the young cane in largely preventing the loss of water from the drains. When the cane is small its root system enables the soil of No. 5 to hold more of the rainfall water than was held back by No. 6. On October 28, however, the cane was much larger, its leaves almost spread from row to row, covering all the ground, and when even the small rainfall of half an inch fell the largely developed leaves of the cane gathered up the rain and conducted it directy to the cane roots in the furrow, where it sank down and out of the drains. The same amount of rain, but which fell evenly over the whole surface of row No. 6, was taken up more gradually by the soil and only 1 gallon of water discharged at the drain.

The general conclusions to which the observations in detail have led may be expressed as follows:

(1) A greater loss of water results from the application of a given volume by irrigation than occurs when the same volume is received as rainfall. The exceptions to this rule are few, and are confined to examples of crops such as the sugar-cane, having a large leaf surface, and which are planted in furrows.

(2) The application of a given volume of water per acre in furrows results in a greater loss and waste than where the same volume is applied by flooding the whole surface of the ground.

(3) A greater loss of water from seepage takes place when a given volume is applied in large quantities at long intervals than when the same volume is applied in small quantities and frequently.

SOME RESULTS OF OVERIRRIGATION.

Effect on the soil.—From the foregoing considerations it is seen that soils can absorb and crops consume only so much water, and that when the applications are in excess of the requirements the surplus must sink into the substrata and be lost. The loss, however, is not covered by the mere waste of the water and the expenditures in getting it onto the ground ;a further loss is caused by the action of the escaping water upon the soil and its constituents. Every gallon of water applied in excess of what the soil and crop can retain and use soaks away and is lost. In draining through the soil it dissolves and carries with it much of those bodies that are soluble in water, and as they are the constituents that the plant depends upon for its food, the excess of water acts as a plunderer and depleter of the elements of fertility of the soil. For these reasons the great damage that follows from excessive overirrigation can not be too strongly dwelt upon nor the practice too emphatically condemned. The more permanent injurious effects of the excessive application of water to soils and crops do not become apparent until the damage is done. Certain effects upon the young crop are soon visible and appear in the yellow color and stagnation of growth. The field manager, however, who knows nothing of the physical and chemical properties of soils, of the relative requirements of water by different crops and at the different stages of their development, does not conceive what is happening to the fertilizing elements applied for the use of the present crop and to the natural constituents of the soil upon which future crops must depend. That ignorance in this particular is costly is confirmed by much evidence from the owners of ruined land.

The city of Honolulu is deluged by irrigation, which is not only impairing the sanitary conditions immediately around the dwellings, but is also leading to the formation of fresh water swamps, which in their turn are vitiating the general atmosphere of the place.

In irrigating alkaline lands, the conditions and rules which must be observed differ from those which control the economic irrigation of sweet soils by sweet waters. If no more water is applied than the soil can hold and the crop can make use of, conditions highly unfavorable to plant life can be brought about. The water that is applied in descending in the soil, dissolves and holds in solution a large amount of the salts, and as the water returns to the surface in answer to the calls of evaporation and plant needs the salts are brought up also and deposited in great excess in the upper stratum or on the surface of the soil. The same result can follow the application of salt waters to sweet soils, of which the writer has noted acute examples upon the Hawaiian Islands. The application of brackish waters or waters charged with chlorid of sodium, magnesium, and lime, even to soils free from deleterious salts, can result in such an accumulation of those bodies in the upper soil that our domestic plants will not grow. The only provision against trouble from the use of saline waters is to use enough to leach the soils and prevent accumulations. To do this perfect underdrainage is essential, and it is further essential to immediately restore to the soil the soluble elements of plant food that have been carried out by the water, along with the injurious salts, or the soil will presently become washed out and sterile. Irrigation of salt or alkaline soils with saline waters is a special matter and demands special treatment, and its requirements must not be confused or mixed up with the factors that exist in normal situations which govern the irrigation of sweet soils with sweeet waters.

Upon the island of Hawaii, which is the largest island in the Hawaiian group, there are several well-defined districts which are distinguished by varying climatic conditions. In the district toward the north the average annual rainfall is some 52 inches; in the middle district the precipitation ranges some 25 inches greater; while in the wet district of Hilo the yearly rainfall is some 180 inches, or nearly 15 feet. Upon the other islands of the group similar variations in rainfall are found, but these variations differ not only with the districts but also with the elevation of the land in the same location. Two examples may be cited of extreme variations in rainfall in the same district due to a difference in altitude. In the one, the rainfall at sea level was 30 inches, while at an altitude of 900 feet it was 118 inches per year, and in the other it was 28 inches at the sea shore and 179 inches at a height of 2,800 feet up the mountain side. The following table gives the results of a partial analysis of the soils taken from these different districts:

Effect of rainfall upon composition of soils.

Land.	Average rainfall.	Chemical constituents of the soils.			
		Lime.	Potash.	Phosphoric acid.	Nitrogen.
	Inches.	Per ct.	Per ct.	Per ct.	Per ct.
Dry	60	0.474	0.324	0.248	0.176
Wet	120	.248	.270	.243	.450

These figures indicate that soils derived from the same lava rocks vary extremely in their chemical composition, and that the chemical difference is the result of the different climatic conditions. The great excess of rainfall over the wet lands has removed the soluble lime and potash, and at the same time has largely augmented the amount of nitrogen, which element is brought from the air and stored up in the soil in the accumulated organic matter. A more specific example is found upon the island of Hawaii in the districts of Hilo and Kau. Hilo is located upon the humid side of the mountain, and the Kau district lies on the side of limited rainfall. The rainfall and composition of the soils are as follows:

Effect of rainfall upon composition of soils.

District.	Average rainfall. Inches.	Chemical constituents of the soils. Lime. Per ct.	Potash. Per ct.	Phosphoric acid. Per ct.	Nitrogen. Per ct.
Kau (dry) ...	56	0.955	0.846	0.606	0.505
Hilo (wet) ...	180	.128	.257	.504	.840

In the Hilo district the rainfall ranges between 160 inches and 210 inches per annum. The table shows the great difference in the proportions of the important constituents in the soils of the two districts, all of which have been derived from the same basaltic lava rocks. The difference in the cane crops grown in the two districts is just as striking. In the Kau district the lands are highly productive when the rainfall is enough to support growth. In the Hilo district the yield of sugar per acre is little more than one-half the crop of Kau in normal seasons; and upon the higher lands in the district, where cultivation of cane has gone on for some ten or fifteen years, the soils are so badly washed out that they have ceased to produce remunerative crops, and great expense is being incurred to restore the depleted fertility. From these examples we see the results of an unusually large precipitation falling upon the ground year after year. Frequently in the Hilo district deluges of water carry the earth bodily into the sea, reddening the ocean a mile out from its shores. The analyses of the soils show that the soluble plant-food elements have been removed, while the crops testify that such is the case. According to the data furnished by Schuyler and Allardt, the Hawaiian plantations are striving to apply by irrigation from 200 to 260 inches of water per crop, with what results, according to the testimony of nature, will eventually be seen.

The writer has been endeavoring to obtain evidence in detail by means of tests made at the experiment station, showing the effects of the excessive use of water upon the soil itself and upon the chemical fertilizers that are applied for the use of the crop.

In the course of the tests made by means of the lysimeter for determining the loss of water when given amounts were applied by irrigation, determinations were also made in one of the series of tests showing the elements contained in the wasted water which had been removed from the soil. In the following example is shown the volume of water that drained out of the soil with the amounts of the more chemical elements carried out in the water during a period of ninety days:

Fertilizing constituents leached from the soil by excessive irrigation.

Loss water.	Constituents removed from soil per acre.		
	Lime.	Potash.	Nitrogen.
Gallons.	Pounds.	Pounds.	Pounds.
58,000	278	61	117

These amounts of the elements were taken out of the natural soil by the excess of water applied during the short period of ninety days. The water that is escaping from a field of newly cultivated ground differs greatly from the drainage water of a whole district whose surface is largely made up of undisturbed grass, forest, or other similar growths. The ground coverings save the soil from the direct action of the water, and where the subsoil has remained undisturbed for a great length of time the percolating waters have wrought out their own channels of escape to the substrata, and the results are that the water escapes very rapidly, but carries relatively little dissolved soil materials with it. It is just the opposite with water falling upon or being applied to freshly broken and cultivated soil. It reaches every particle, saturating and acting upon its soluble constituents, and, according to the length of time that the water occupies in passing through, is the amount of solid matter contained in the drainage. The great difference in the amounts of solid matter contained in general drainage waters and in waters escaping from a newly broken soil in a high state of cultivation in the same district is as follows:

	Per cent.
Solid matter in general drainage water	0.0537
Solid matter in water from fresh soil	.7200

These figures indicate that the amount and character of the solid matters contained in the drainage waters of a vast watershed can not be taken as showing the solid soil elements which are being leached out of cultivated areas by excess of water. It has also been observed that the water escaping from cropped fields that have laid still and have been irrigated regularly for a considerable length of time does not contain as much solid matter as was found in the first leachings from the fresh soil. In the course of time the water works its own minute channels of escape through cultivated grounds, when the water escapes more rapidly, but carries less material with it. In the lysimeter tests this action of the applied water in working down its own lines of escape became so very pronounced that the experiments had to be stopped until the drains were all renewed and the soil rendered homogeneous again.

The escaping water not only carries with it the elements of plant food present in the natural soil; it also acts ruinously upon several of the elements contained in artificial fertilizers that are applied at great cost to growing crops. The following table shows the water and chemical elements contained in the water lost per acre during ninety days. In one test the ground was planted with cane; in the other the ground bore no crop.

Chemical constituents contained in drainage water.

Land.	Loss of water. Gallons.	Loss of constituents per acre. Lime. Pounds.	Potash. Pounds.	Nitrogen. Pounds.
Cropped land	57,250	467	73	325
Bare land	92,250	1,140	215	561

The first thing observed from these figures is the action of the growing crop in reducing the loss of water, and consequently of the fertilizing elements. The loss, however, especially upon the land bearing no crop, is enormous. Yet this loss is not greater than has been observed in the open field and on a large scale. In the district of Hilo, Hawaii, already spoken of, the lime content in 1 acre of soil to the depth of 1 foot is less than 4,000 pounds. In the dry district of Kau, on the arid side of the mountain, the lime content is not less than 35,000 pounds per acre to the same depth, thus indicating that some 30,000 pounds of lime per acre have been leached out by the great rains. The considerable amounts of nitrogen leached out require no explanation, as the soluble and wasteful behavior of the nitrates is well known, as also the action of nitric and hydrochloric acids in plundering the lime content of soils. These phenomena, then, exhibit very clearly the ruinous effects of excessive application of water upon natural soils and upon the artificial fertilizing elements that are applied to crops.

Effect of excess of water on crops.—The results to growing crops that follow heavy and continued rainfalls are matters of common experience and often causes of widespread loss. No fact is more thoroughly established in agricultural experience than this one: That while a moderate rainfall is indispensable to growing crops, an excess of rain is the cause of immediate loss in the crop and of damage to the soil. In the wheat districts of Europe every farmer knows what he may expect from a dry spring; but if the month of May is wet as well as cool he also knows that the yield may be cut down by one-third.

In the series of tests that were made at the Hawaiian Experiment Station to determine the amount of water that could be applied to the cane in furrows before leaching and loss of water took place concurrent observations were made upon the effect of applying different volumes of water upon the germination of the cane seed and the subsequent growth. The character of the soil of the three plats included in the test was the same. The cultivation and fertilization were also the same. The cane seed was all selected and each plat was planted the same day. At the time of planting and afterwards the plats received, respectively, 1 inch, 2 inches, and 3 inches of water per week and with the following results:

Plat 21.—One inch of water per week; cane found coming through the soil on the sixth day after planting.

Plat 23.—Two inches of water per week; cane coming through the ground the eighth day after planting.

Plat 25.—Three inches of water per week; cane coming through ten days after planting.

It is thus seen that the cane seed receiving 1 inch of water per week germinated and came through the ground four days in advance of the cane seed receiving 3 inches of water per week. The relative number of the cane seeds that grew in the plats receiving the different volumes of water is shown in the following table:

Number of plants germinated in plats receiving different quantities of water.

Plat.	Water applied weekly. Inches.	Seed—pieces. planted.	Seed—pieces that grew.	Seed—pieces that died.
No. 21	1	802	706	96
No. 23	2	802	698	104
No. 25	3	802	628	174

On October 1, four months after planting, the canes were all counted in each of the three plats, the number found being as follows:

Number of canes growing at the end of four months in plats receiving different quantities of water.

Date.	No. of plat.	Depth of water applied per week. Inches.	Number of canes in the plat.
October 1	21	1	1,995
do	23	2	1,701
do	25	3	1,599

From the data contained in the previous tables and statements it is shown—

(1) That the larger the volume of water applied to the planted cane seed in excess of 1 inch in depth the greater was the time required in germination.

(2) The greatest number of cane seeds died where the largest volume of water was applied.

(3) The greatest number of canes was found four months after planting where the least volume of water was applied.

It is to be noted that the above data apply to the cane at the time of planting and during the early stages of growth. With greater development, and especially at the stage of maximum growth, the consumption of water will be considerably greater until 2 inches per week will be demanded.

In the germination of the cane seed or of any other seeds the supremely essential factor is the oxygen of the air. Without the presence of the air and a moderate amount of moisture germination can not take place. On the other hand, when the ground is filled with water and kept in a saturated state, the air normally present in wholesome soils is driven out and replaced by the water; consequently the first essential to a rapid germination and growth is removed. Again, in the presence of an excess of moisture and a dearth of oxygen the germination is not only slow, but it can be stoppped after having begun, and the seedling dies. These principles are illustrated in the tests already cited, where it is seen that the cane seed which received the great excess of water not only was four days longer in coming through the ground, but that a relatively larger proportion did not come up at all, having died in the ground. The application of an excess of water can also create another condition highly detrimental to a rapid and healthy germination. Irrigation water, which comes either from high altitudes or from underground wells, is generally very much cooler than the soil to which it is applied. In the tests made the temperature of the soil to a depth of 6 inches was 88° F., while the water was 72° (the writer has found the temperature of some underground waters on the Hawaiian Islands to be 25° cooler than the air). The pouring on of a large excess of water of relatively low temperature immediately reduces the temperature of the soil, and thus makes another condition unfavorable to healthy germination and rapid growth. In cane-sugar countries, where the rainfall is liable to be considerable and the temperature of the soil is low at the time of planting, the cane seed will lie for weeks before coming up, and in unfavorable seasons much does not germinate at all.

In one series of tests conducted by the writer, in which it was sought to include all factors conducive to growth and to avoid any unfavorable conditions, the irrigation was begun and is being continued as follows: The seed was planted in dry and thoroughly cultivated and porous soil and sufficient water was applied to cover the ground to a depth of 1 inch. This amount was equal to a depth in the furrow, however, of 2.5 inches, which sank down and wet the soil to a depth of 6 or 8 inches below the seed bed. The application of 1 inch per week was repeated and continued for a period of four months. Not only at the time of germination, but even up to the end of three months after planting, the seed and the young cane could not consume anything like 1 inch of water per week.

Until the plant began to shade the ground considerable evaporation took place. The volume of water lost in this manner was much greater than that consumed by the young plant. This was clearly shown by the result of evaporation and transpiration tests. With the increased development of the cane its consumption of water was greater, but the increased foliage protected the soil against the sun, and the loss of water from the soil itself became less. This demand for an equal volume of water each week was maintained until the crop was four months old, when the ground surface was completely covered by the cane foliage. At this time the crop was rapidly adding to its substance. Cane stalks were well developed and the consumption of plant food and water was vastly augmented. In the fifth month of its age the appearance of the leaves showed that the cane required a somewhat increased weekly allowance of water, and this was confirmed by the moisture found in the soil, which was down to 18.5 per cent. The soil in question has a capacity for taking up 48 per cent. of its own weight of water, and the effort is made to prevent the actual moisture in the soil from sinking below 20 per cent. and from raising above 30 per cent., the conditions of growth being most favorable when the moisture present in the soil is equal to about one-half of its maximum water-holding capacity. The exceptions to this rule are controlled by the temperature. In cool weather and low soil temperature the water in the soil should be kept low; in warm growing weather the moisture in the soil should be higher, but the point of saturation should never be reached or growth is impeded or stopped. In the fifth month more water was applied, the amount being increased to 1½ inches per week. The cane could not bear the extra half inch every week, and alternate weeks only 1 inch was applied, until the greatly increased growth demanded not only 1½ inches weekly, but even 2 inches if the winds were very drying.

As the cane gets older its root system develops proportionately, running not only in all lateral directions, but deeper where the soil allows. It is therefore good practice to increase the volume of irrigation so that the soil moisture reaches as low as the roots penetrate. In fact, the moisture should be kept a little lower than the roots, in order to induce them to feed deeper. An extra irrigation of half an inch, and even an inch, may be given to be sure that the moisture content is maintained below. This moisture at a greater depth is not only required to cause the plant to feed deeper, but it is indispensable for the purpose of rendering the more insoluble matter of the subsoil soluble and ready for the future use of crops.

At the time this report is written the cane in the tests in question is ten months old. The cane stalks are some 8 feet in height, and the crop is so heavy that it lies nearly flat and almost shuts out the sun. During a week of warm, sultry weather it consumes 1.5 inches of water. If the air is clear and warm, and a dry wind prevails, 2 inches per week are given; but if cool nights and average days prevail, only 1 inch of water is given per week. The cane is in perfect health and growth; the moisture is maintained in the soil, as attested by the analyses; and no water escapes, as indicated by the observation drains. The object in irrigating sweet soils with sweet water is to meet the demands of soil evaporation and of traspiration by the crop, and to maintain an equilibrium of moisture in the soil relative to its maximum water-holding capacity, and to avoid leaching and loss.

SOME GENERAL OBSERVATIONS.

In the course of annual visits of inspection made by the writer to all districts upon the several islands of the Hawaiian group during the past five years, ample opportunities have been afforded to observe the methods of irrigation in general practice and the results that have followed the application of water. There are districts, such as have been already described, where the temperatures are high and the rainfall very small, and where crops could not be produced without the aid of irrigation. In most of these arid districts the soils are deep and of great fertility, which is largely due to the absence of heavy leaching rains, such as obtain in wet districts. The application of water to those deep, rich soils has resulted in the production of enormous crops. Those lands are still virgin so far as concerns the length of time they have been under cultivation, not more than four to eight crops having been taken off. It may be that the present methods employed in irrigation will in time injure the land.

If there is any change in this respect it is not now evident. It is possible that overirrigation in certain localities, if not corrected, will render the lands nonfertile before the twentieth crop has been reached. The following paragraph is taken from the annual report of the present manager of one of the largest and most fertile plantations on Hawaii:

"It has come under our observation that the mechanical condition of the soil in the older fields, owing to the action of nitrate of soda (and heavy irrigation), is not as good as that of virgin fields immediately adjoining. * * * It is apparent that any water passing through a soil, and beyond the cane roots, carries with it a certain amount of soluble matter, whether it consists of fertilizers applied or natural fertilizing elements in the soil. Therefore any water beyond that taken up by the cane is engaged in a leaching process that is detrimental. Thus, in spite of the generous fertilizing that has been carried on upon this plantation, some of the older fields show a decrease in available potash and lime.'"

The plantation here referred to is new, none of its lands having produced more than five crops. Since the lands were cultivated and the cane crops heavily irrigated evidences of excessive irrigation have made themselves clear. When the water is applied to the lands on the higher levels in excessive quantities the excess percolates through into substrata, and reappears upon the surface of lands at lower levels. In this particular example numerous so-called "springs have broken out on the lands next to the sea since the irrigation of the fields above." Upon another island a manager of one of the plantations replied to the writer, in answer to questions: "Oh, yes; after every irrigation those gulches run a pretty good stream for the next twenty-four hours." The gulches in question are the low places to which the watersheds of the fields converge, and through which the excess of water applied in each irrigation finds its outlet to the sea. I have seen costly fertilizers, in bags, thrown into the ditches to be dissolved and distributed by the water, and consequently to be carried to the sea by the excess of water that found its way there. In another case the manager of the plantation said to the writer:

"So much water used to be run onto this field that it seeped out after every irrigation into the deep ditch running across the bottom end of the field; from that ditch it was turned into the field below and used over again. But now we put on less than half the former quantity and irrigate oftener, and there is no waste."

In one other case the plantation manager remarked:

"We have had wonderfully fine springs of water in our low gulches since those upper lands have been irrigated."

A few statements of a different kind have been received from plantation managers who were open to argument upon the methods of irrigation. One gentleman writes:

"The recovery of that field of ratoons from the horrible yellow state in which you saw it, and the yield of sugar, were due to lessening the supply of water before it was too late."

Another manager wrote:

"The half of the field which has received just one-half of the usual allowance of water is better cane and the juice is of better quality than the cane upon the other part of the field getting the old amount of water."

Unfortunately the number of these testimonials is small, most of the managers preferring to continue in the old way. A new factor, however, is beginnning to operate in certain districts. So much land is being devoted to sugar cane, causing an increased demand for water, that the supply is already insufficient. It now appears that water will have to be very economically handled in order to make it cover increasing demands. Economy in use is, therefore, a factor with which the managers of our irrigation matters will have to deal, and when that is accomplished, the day of the scientific irrigator will have come.

LABOR CONDITIONS OF HAWAII.

(From the annual report of the Governor of the Territory of Hawaii for 1904.)

As the sugar and rice industries of the Hawaiian Islands are the only ones employing agricultural or other laborers in large numbers, the needs of the Territory in respect to the numbers, nationality, and kinds of immigrants desired reflect to a large extent the needs of those two industries. At the present time there is, outside of the sugar and rice industries, very little room for the employment of unskilled laborers. In time to come other industries may be established which may employ a number of laborers, but there is now a necessity for only such class of laborers as can be utilized in the cane and rice fields and in other branches of the sugar business.

The conditions which exist here render it imperative for the preservation of the industries established that laborers be brought from abroad.

Most tropical sugar-growing countries either possess an indigenous laboring population, available for the cultivation of sugar cane, or have within easy reach people who are readily obtainable for tropical field work, and whose physique and constitution enable them to undertake such field work without fear or injury to their health.

There is not such an indigenous population here to supply the demands, and the tendency of the native population is not toward field work. They make good mechanics, and a portion of these are engaged in a variety of trades, but agricultural labor appears to be distasteful to them, and the number employed on sugar estates is small. This being so, it has for many years been necessary to promote immigration of field laborers to the islands, and many countries have been drawn from. There has been regularly conducted emigration from Germany, Norway and Sweden, Azores, Madeira, Portugal, Galicia, China, Japan, and Porto Rico, besides which British, Americans, Italians, and negroes (from the United States) have come in small numbers.

Under the laws of the Kingdom and later of the Republic of Hawaii, immigration from European countries was assisted by the government and industrial interests of Hawaii. Since annexation to the United States it has entirely ceased, as assisted immigration is prohibited by the United States immigration laws, and it is quite impossible to direct a voluntary immigration from Europe direct to Hawaii, the great distance and expense of transportation being insurmountable obstacles in the way of such voluntary immigration.

So far as the Europeans and Americans are concerned, it has, with one exception, been found that they were unfitted for tropical field work; they could not and would not perform it, and never for long labored as "field hands." The one exception noted is that of the Portuguese from Madeira and the Azores, who showed themselves capable of performing good field work. The improved condition of their own countries no longer necessitating immigration, these people show no disposition now to come to the islands, and even if they were willing to emigrate to Hawaii the laws of the United States would hinder them from receiving that assistance without which immigration would be for them impossible. And here it may be stated that if other Europeans can be found who could endure labor in the cane fields of Hawaii, the immigration laws would render them unable. The geographical position of these islands and the great distances which such emigrants would have to travel would necessitate their being assisted in ways which are prohibited by the laws, as they can not themselves meet the cost. Of the Portuguese who originally came to Hawaii as assisted emigrants, those who did not go to the mainland have so prospered that now they do not engage to any large extent as plantation laborers, and their children, by the aid of the excellent Hawaiian free-school system, have fitted themselves for more congenial occupation than field labor affords.

It has sometimes been argued that the Hawaiian sugar industry is in exactly the same position as that of the Southern States, and that if the latter can supply their labor needs, Hawaii should be able to do the same. This, however, is wholly misleading and untrue. If Hawaii had a large indigenous population such as exists in the Southern States, and if Hawaii could draw upon the large streams of immigration entering the United States, from which to supply its requirements, as does that section, then such a comparison might be made. If there were no indigenous population upon which the Southern States could draw to supply the labor required in the fields, and were they wholly dependent upon Italian and other European immigration for labor, they would stand in relation to Europe geographically as does Hawaii in relation to Asia. Furthermore, while there is a stream of Italian and European immigration from which the Southern States can supply their needs, the great distance to Hawaii, coupled with the rigorous laws against assisted immigration makes it impossible for Hawaii to hope for relief from that source, even if such immigrants could stand the climate, which is far more trying than is that of the South. It must be remembered that the Hawaiian Islands are situate south of the Tropic of Cancer between the nineteenth and twenty-first degrees of longitude, consequently on or about the same level with, for instance, Vera Cruz, Manzanillo, Hongkong, Bombay and Burmah, Cuba, Formosa, and Mexico City.

The impossibility of securing a sufficient supply of Hawaiian or other laborers able to endure the work in cane fields forced the planters of these islands into a reliance on China and Japan for the necessary supply. The Chinese have always proved themselves to be a law-abiding, docile and industrious people, but the United States exclusion laws shut out this nationality from Hawaii as soon as annexation became an accomplished fact, and the only present practicable source of supply is Japan, though a small number have come from Korea.

Since the annexation of these islands the difficulty of maintaining an adequate suply of agricultural field laborers has been very great. Chinese are absolutely prohibited, and while the Japanese still come, the number of immigrant laborers hardly balances the number of Chinese and Japanese who return monthly to their homes, and the scarcity of labor has enchanced its value.

There exists in the minds of some, who are unfamiliar with the nature of field work in a tropical cane field, the impression that white men can perform the work, and that the proper way to conduct a sugar plantation is to divide the land into small lots and give them to white men to cultivate instead of doing the work of cultivation by day laborers working for a wage under one controlling management.

A list of the nationalities that have tried field work in Hawaii has already been given. Today there are no white men laboring in cane fields here. Those who have tried it have never stayed by it for any length of time, and abundant evidence is forthcoming that the white man can not and will not stand the work of tropical cane fields.

Some little time ago the management of the Ewa plantation, on the Island of Oahu, decided to experiment with American farmers. Fifteen families of highly respectable people were carefully selected in the Western States, and all their expenses paid to the plantation, where houses had been erected for them, each with a garden patch surrounding it, and where a large patch of "common land" had been set apart for their use as pasture for such stock as they desired to keep. Here they were given lots to cultivate in cane, and every help was rendered in the way of plowing and preparing their fields, but notwithstanding this and all the Ewa Plantation Company expended on this effort to raise cane by white farmers, these people were not able to perform the necessary labor, and they drifted away by degrees, so that in about a year none of the fifteen families was left. Other experiments of a similar nature have been made with like results.

In connection with the question of "homesteading" and of encouraging small farming, it is proper here to point out that all the lands cultivated by plantation companies, who find it necessary to irrigate because of the uncertainty of the rainfall, were either arid wastes or poor pasture lands before they were acquired by these companies, who sank artesian wells, established expensive pumping plants, or constructed extensive water ditches and pipe lines, and at great cost poured water over the lands and made agriculture thereon a possibility. If development by homesteads only had been possible the lands which are now cane fields would be in their primitive condition, because their irrigation was only rendered possible by the investment of a large amount of capital.

With the largely increased world production of sugar, it is only with difficulty that cane can be grown here with a profit. The remoteness of these islands from the world's market and the cost of production are factors to be contended with.

It would be of great advantage to the agricultural interests of these islands if the United States immigration laws could be so amended as to permit the assisting of a desirable class of Portuguese laborers from the Azores or neighboring islands, or if there could be a modification of the Chinese exclusion act permitting the immigration to these islands of a limited number of Chinese agricultural laborers, such laborers to be restricted to agricultural labor and domestic service, and strictly prohibited from engaging in mechanical and mercantile pursuits; such immigration to be so regulated that the identity of each laborer may be ascertained and a record kept thereof, and that he may be required at the end of from three to five years from the date of his arrival in these islands to depart therefrom, and that such laborer be not permitted to go from these islands to the mainland. The Organic Act takes care of this now. No Chinese can go to the mainland from Hawaii.

Under the existing laws of immigration it is impossible for Hawaii to get immigrant classes from Europe or other occidental countries. Hawaii is 5,000 miles from the point where the great numbers of immgrants land in the United States. Hawaiian interests have tried the experiment of bringing immigrants from Atlantic ports of the United States to Hawaii, and have failed. We are therefore forced to take immigrants from the Orient or go without, and to go without means the ruin of Hawaiian industries, a condition that the Congress of the United States can not afford to permit, much less to exist, as it certainly would be making a failure of the industrial situation in Hawaii by the continued application of such a drastic measure. No class of American citizens would be injured by the special legislation above referred to, permitting a restricted immigration of field laborers from China; on the contrary, the interests of all Hawaiian citizens and producers as well as of the planters themselves would be furthered by such legislation. The population thus created would increase the Hawaiian market for American products and be for the direct interests of workmen on the Pacific coast and in all industries supplying goods to the Territory, while it would not be a competing element upon the mainland.

By the acquisition of distant territory in the Pacific Ocean the domain of the United States is extended in such a degree that in making laws existing conditions should be recognized. In matters of immigration, the restrictions which are required for the protection of the mainland may be very injurious for distant possessions, and a distinction should be made by special legislation so that classes not desired on the mainland can be excluded, and the distant possessions provided for as their needs may require.

THE FEEDING OF MOLASSES TO WORK STOCK.

(An address by Dr. William H. Dalrymple, M. R. C. S. S., Louisiana State University Experiment Station, Baton Rouge, before the Louisiana Sugar Planters' Association, May 11, 1905.)

Mr. President and Members of the Louisiana Sugar Planters' Association:

While highly appreciating the compliment of being invited to present a paper a this meeting on The Feeding of Molasses to Work Stock, I fear the invitation came before I had sufficient time to properly masticate, digest, absorb and assimilate the data which I have, during the past few weeks, been endeavoring to collect with the view of embodying the results and conclusions deducible therefrom in a bulletin which we hope to issue, in the near future, bearing upon the subject. In fact, I am still only at the first, or preliminary, stage in the process of digestion, viz: prehension, or, in other words, getting hold of the raw material. Still, the subject of animal nutrition, or dieteties, as applied to the "motive power" on the sugar plantation has always been one of such keen interest to me—more so, I sometimes imagine, than to some stockowners, that I am glad when the opportunity presents itself to be able to say a word which may, perhaps, result in a monetary saving to the owner through reduction in the feed bills; the maintenance of a more excellent bodily, or physical, condition of the animals for the better performance of the work required of them, and a decrease in the painful and often fatal digestive ailments consequent upon an unnatural or irregular system of dietary; all of which, latter, tends to bring about a more humane condition of affairs, with regard to this hard-working and faithful animal—the mule, which I think, as all will agree with me, should not be lost sight of in our effort to get the most out of him.

As no doubt some of you are aware, I have recently been sending to a number of leading planters throughout the State, a blank, containing a set of questions relative to the feeding of "black-strap" molasses.

I may say, that by no means all to whom I addressed questions regarding the feeding of molasses, have made reply. Those I have received, however, comprise quite a most interesting and varied mixture, ranging from answers containing two words, to some, giving the most minute detail, and for which the paper, both front and back, was hardly enough. There are still some planters, I find, who do not use molasses, but they are exceedingly few, indeed. All who do feed it, claim a reduction in cost of food over previous systems, without molasses, of from about 10 to 60 per cent. Some express the economy one way, others in another way, while some are not quite certain, and yet others who have never figured out the saving. Some there are who still stick to corn and oats as concentrates, while others believe in the "good old Creole corn." One planter states, that, previous to three years ago, he fed no molasses; fed only twice a day, and did not grind the feed. Since feeding the "new way," viz: Feeding the molasses along with the other concentrates, which are ground, and the hay chopped, and all mixed together and divided into thee feeds, he has made enough food material on the plantation, and has had to buy practically nothing.

On another plantation, working 177 mules, the annual saving has amounted to $6,000.

Another planter states, that since feeding molasses, the cost of feed per day and per head is 19 cents, while, not many years ago, he could not feed any cheaper than 35 to 40 cents per head per day.

Another prominent planter expresses himself in a still more comprehensive manner. He says: "You already know my opinion on the subject of the 'balanced ration.' Besides the great saving in dollars and cents, not only in feed, but in the freedom from loss of animals, and in the increased efficiency of the animal organism, this replacing, or partial substitution of molasses for corn has made it possible to decrease corn acreages down to such a point that the latter no longer interferes with the fall planting of the cane crop, and its rapid and prompt cultivation in the spring. By this reduced corn acreage, due to the 'balanced ration,' and cheap and economical feeding, it brings within reach the accomplishment of the ideal, and the ideal is the planting of practically all the cane crop in the fall. * * * * * * Economic feeding, besides being itself in line, scientifically, its practice makes possible the doing of many more things in the right way. Its application to our agricultural conditions is, in my opinion, a greater step than the utilization of bagasse as fuel, or the concentration of juices and syrups, in vacuo, has been in the economic operation of our sugar houses. This planter estimates the economy of feed over previous methods, at 15 cents per head per day."

I do not wish to bore the Association with quotations, and will add only another. The owner of the plantation in question states. "That in connection with cotton seed meal, and ground corn and cob, it (molasses) furnishes a perfectly balanced ration for a lesser price than any other ration." And, I believe I can take it upon myself to say, that this particular planter has reduced his feed bill, at the very least, 50 per cent.

I find some who think molasses has no nutritive value, but that it merely entices the animals to consume more of other materials with which it is mixed, by rendering them more palatable. Still others, who think that molasses is not of sufficient solidity upon which to expect the animals to perform hard work, and should, therefore, under such conditions, be replaced, to some extent, by a more solid and bulky food.

Some feed molasses as an ingredient of a mixed ration; others, by itself in an open receptable—*pro bono publico*, so to speak; while still others adopt both methods.

Quite a few know the exact amount each animal consumes per day, as well as the other ingredients of the mixed ration, and can, therefore, make a close computation as to the cost of feed; while quite a considerable number make guess work of it, and have really no accurate conception of the amount utilized by the stock.

The fewer number of planters feed their animals three times per day; the majority, twice.

The consumption of molasses per head per day, on 42 plantations in different parts of the sugar belt, up to the time of preparing this paper, averages about 9.5 pounds; the range being from 2 pounds to a little over 21 pounds.

I think I can safely say, that all who are using molasses concede to a considerable saving in the feed bills; a large diminution in the number of cases of dietetic ailments, such as colic, etc., and the health, and, therefore, the condition of the animals, for work, very much improved; which, latter result, should certainly be taken into consideration when estimating the matter from the standpoint of economy, which, as I take it, is the gist of the whole thing.

This, gentlemen, is a somewhat loose summary of what is being done, on a fair average of the larger sugar estates of the state, in feeding molasses to the work stock, based upon the replies received up to the time I began the preparation of this paper.

Of course there is considerable amount of repetition of detail with regard to the other ingredients of rations fed, which would occupy time uselessly, I think, to enumerate on this occasion, and in fact, make it difficult for me to offer intelligent deductions, in the limited time I have had at my disposal.

The main result, and the one which we are still most desirous of obtaining, in the feeding of molasses, is, its being a most important factor in materially reducing the cost of feeding; as a valuable conserver of the health and condition of the animals, and, therefore, of their physical ability to perform more and better work. All of which means a balance on the credit side of the live stock account of the planter. This fact is conceded, without exception, I believe, by those gentlemen who have responded to my inquiries regarding the feeding of molasses.

But, there are a number of other points suggested by many of the replies, which call for some passing consideration at least.

I wish some one would coin and substitute a word (easy of comprehension by everybody) in place of the term "science," that apparent stumbling block in the minds of so many, although it means, simply in our connection, "knowledge gained by systematic observation, experiment and reasoning," according to the Century dictionary's definition of the term.

Someone is reported to have remarked, during discussion, at the last meeting of the Association, that, "Practice beats science all to smash." While, at the same time, the gentleman making the remark "was a great admirer of knowledge," or something to that effect, evidently overlooking the fact, that the true object of scientific investigation is to bring knowledge, gained by scientific observation, experiment and reasoning, just alluded to, down to a practical basis. In fact, the more truly practical a thing is, the more scientific it is, and vice versa.

There is quite a difference, however, between information acquired as the result of ordinary observation, and knowledge obtained from scienticfic investigation. For example, we may know, by ordinary observation, that an animal has eaten—swallowed, that is, 30 or 40 pounds of oats in the course of a day, and, if no ill effects suprevene, may at once decide that that is the correct quantity, because we know the animal ate it, and without any untoward after-effects.

Science, on the other hand, or knowledge gained by systematic observation, experiment, etc., will tell us that there is a limit to the digestive powers of the animal, and that the quantity, in excess of a certain amount, dependent upon certain conditions, is not only not digested, but materially interferes with the more perfect digestion of the necessary quantity, and, besides being an absolute waste of food, is an unnecessary tax upon the digestive organs, and a menace to the animal's health and life.

Again: Many of us know, from ordinary observation, that good timothy hay is a good hay, and we also know that we have paid 20 or more dollars per ton for it. Science has been able to inform those Western timothy hay growers, that if they will shred up their corn fodder and feed it at home, they will get about the same nutritive value out of it pound for pound as the timothy contains, and they can ship the latter down South where they can obtain the prices for it which we have been in the habit of paying. In short, the digestible nutrients contained in timothy have been costing us at the rate of, say, \$20 per ton of hay, while the hay grower in the

West has been getting a similar amount of nutriment, from a ton of corn fodder, for probably less than one-quarter the cost.

There can be no antagonism between correct practice and true science, because they are indissolubly linked together.

In looking over the total amounts of food given, and from past experience, I am very much inclined to the opinion that, for best results, many planters allow a too liberal supply, both of concentrates and roughage, but more particularly, perhaps, the latter material. Many seem impressed with the idea that work animals ought to have all the food they can put out of sight, but evidently forgetting that perfect digestion has its limitations, and, also, that our work stock are, as such, not under natural conditions, and have to, or ought to, be governed in their dietary by the higher intelligence of their owners.

Prof. Fred Smith, Lecturer on Veterinary Hygiene, in the British Army Veterinary School, states in this connection, that, "horses performing slow work are necessarily dieted differently from those performing fast work. Work of a laborious nature, be it in the hunting field, or between the shafts of a heavy cart, cannot be performed on a full stomach—distress is rapidly brought about by the pressure of the stomach against the diaphragm, and the consequent obstruction to the free action of the lungs. During fast work the stomach should practically be empty. Horses should, therefore, be fed one or two hours before they are required, and the food given should be of a concentrated character." This hardly agrees with the engorged condition with bulky food in which many of our work stock are required to go to work during the hard-working season of the year.

Now, it is a fact, that the progressive dairyman and the feeder of beef cattle both desire to see their charges go to the limit of their appetites. But here we have a very different system of digestive apparatus, constructed specially to accommodate large quantities of both concentrated and bulky food, and especially the latter; which, however, is returned to the mouth for more perfect and final mastication before it passes to the true digestive compartment of the stomach. Not so, with the relatively small, single stomach of the mule. The food once swallowed cannot return, and hence the necessity for thorough mastication of smaller quantities at a time, before it is fit for gastric and intestinal digestion.

This has more special reference to those foods requiring preliminary preparation in the mouth by the teeth and the action of the salivary ferment, such as the grains, hay, etc., but not so much to molasses, which is already in soluble form, and, therefore, in a condition for absorption without having to undergo the preliminary changes required by the other food materials mentioned.

I think there can be no reasonable doubt that the salutary effects from the feeding of molasses, exhibited in the improved condition of the animals, and their freedom from indigestion, colic, etc., likewise the great reduction in the number of fatalities, is due to its *almost perfect digestibility in its original* state, and having to depend but little, if at all, on preparation before reaching the stomach and intestines.

This brings up a point, and a most important one, which every feeder of animals should be familiar with, but which, from some of the replies sent in, quite a number, I am inclined to think, do not fully realize: That besides a certain bulk, which seems necessary to digestion in herbivorous animals, the only valuable constituents of a food—the only parts that go to nourish the animal—are those only which are capable of solution by the various ferments and juices with which they come in contact in the digestive canal, and can be absorbed by the delicate capillary blood vessels in the walls of the stomach and intestines, and the tiny lymphatics, known as lacteals, which have their origin in the minute process, termed villi, in the mucous membrane of the small bowel; the great bulk of the food, as we know it, being passed out as excrementious matter. It is feasible to presume, then, that if foods like the grains, hay, etc., are not rendered capable of solution, through failure of the necessary preparation before reaching the stomach and intestines, they cannot possibly be absorbed, and, therefore, not being in a condition to enter the blood stream, cannot nourish the animal organism, no matter what the amount of raw material the animal may have swallowed. In the case of our cane molasses, which contains such a high percentage of sugar, practically all of which is digestible, and is already fit for absorption, after being further liquified by the digestive fluids, it is different. And this, I believe, accounts in the main, for the improvement in the health conditions of the work stock since this material was adopted as a part of their food supply.

With corn, which is a highly starchy food, and especially when it used to be fed as an almost exclusive grain ration, dietetic troubles were much more in evidence, due largely, no doubt, to the long-interval system of feeding, favoring rapid and imperfect mastication, but chiefly, and in connection therewith, the imperfect conversion of starch to sugar, which is necessary before absorption can take place; starch, as such, being insoluble, and, therefore, unabsorbable.

"All that a horse or mule can eat," therefore, is by no means necessary to insure the best results, either as to health, or condition for work. There are many striking illustrations of this fact, but one of the most forcible is that given in Prof. N. A. Henry's valuable work on "Feeds and Feeding," where he makes reference to a paper read by the late

Dr. Chas. Hunting, M. R. C. V. S., of South Hetton, England, before the Newcastle-on-Tyne Farmers' Club. The application is more to variety in feed as against a single dietary, but the record of the amount fed is very striking, and for illustration will suit our purpose here. I might state, that Dr. Hunting was widely known all over England, and was, perhaps, the pioneer in the economic feeding of large numbers of work horses, having under his supervision, at one time, some 7,000 animals belonging to several collieries, or coal mines, in the County of Durham. In this particular case, he was called to one of these collieries using 149 head of horses, all of which were large, measuring from sixteen to sixteen and a half hands high, to investigate their unsatisfactory and generally run down condition. The output of coal per day was very much decreased, owing, as he states, to the horses being unable, from want of condition, to get the work out. The animals were miserably poor, though allowed 168 pounds of old oats, and 154 pounds of hay each per week. The oats and hay were both fed whole. These horses worked very long hours and pulled heavy loads, but I must confess, says Dr. Hunting, I was astonished at their appearance after many months of apparently liberal feeding. Their food was changed to 109 pounds of mixed crushed grains (including peas, barley and oats, with wheat bran) and 98 pounds of hay, which made a reduction in the total amount of both grain and hay, of 115 pounds per head per week. Or, in other words, by the previous system each animal was getting a total of 322 pounds of food each week, and which the change reduced to 207 pounds. There was quite a saving in the cost, of course, but besides that, the digestive organs of each animal had 56 pounds less hay, and 59 pounds less grain to digest each week. The result of the change, according to Dr. Hunting, was, that in three months these animals were in excellent health and condition, and capable of performing all the work required of them. I allude to this illustration to emphasize the point, that, animal nutrition is not in direct ratio to the amount of food taken into the body. Or in other words, the amount of food a horse or mule can eat at one time, under the abnormal conditions in which it is placed during work, and the amount digested, absorbed and assimilated, are two entirely different propositions. And, in my humble judgment, it is a want of familiarity with this important physiological fact, that is responsible, in a great measure, for the waste of food materials, the indifferent condition of the animals, and the comparatively high death rate from dietetic ailments, which have, hitherto, prevailed on many of our plantations.

With the evidence before us, gathered from the experiences of a number of planters who have now used cane molasses for some time, we cannot but claim for it a very high feeding value; but by itself, it is not, of course, a perfect food, as it contains only one, we may say, of the important elements of nutrition. It is a valuable food material for, at least, three reasons: (1) It is the cheapest source, at present, at all events, of the carbohydrate nutrient, viz: sugar; (2) It is extremely rich in carbohydrates, containing in the case of mill molasses about 65 per cent.; (3) The complete disgestibility of its contained carbohydrates. And, I am of the opinion, as previously indicated, that the marked success which has attended its adoption, is almost entirely due to the readiness with which it can be absorbed by the animal.

In looking over the replies sent in, I notice that it is the few who seemingly pay any attention to the balancing of the digestible nutrients contained in the ration given the animals. Or, to express it another way, the "grouping" of these nutrients. Only the other day I observed a short selection, from Harper's Bazaar, on the grouping of foods, which attracted my attention. It was given for the benefit of housekeepers, but is not without its application in this connection. It is as follows: "Many otherwise excellent providers do not seem to understand the grouping of foods. This may seem an odd expression, but it means just this, the keeping of meals to an average as far as their nourishing qualities are concerned. For instance, the heavy, rich soups, such as pea, bean, mock turtle, and ox-tail, should be reserved for the days when the meat course is lighter, or even absent altogether. To serve a thick, black bean soup with a roast beef dinner one day, and a light cream soup with a fish dinner the next, is not maintaining the average. * * * * In these days of high-priced meat, it especially behooves the housekeeper to study for food values."

The author of the extract did not enter into technicalities, but the "nourishing qualities" spoken of are the digestible protein, carbohydrates and fat, terms which I feel sure you have all heard a good deal about from time to time, in connection with feeding, and the example of "thick black bean soup with a roast beef dinner," was by way of illustrating a one-sided, or badly balanced, ration, containing in the beans and roast beef, too much of the protein element, because both of these are specially rich in that nutrient. And, the admonition to housekeepers, "to study for food values in these days of high-priced meat," might, perhaps, be accepted and acted upon with profit by the feeders of work stock, especially when so many mouths have to be filled in order that the work may be carried on which is required of them.

Although remarkable improvements in feeding is manifest in the past year or two, it has often occurred to me, that if owners, or those in charge of our valuable plantation work stock, would endeavor to familiarize themselves a little more with the average composition and percentage digestibility of our common available feeding materials, and how to intelligently group, or balance them to meet, as nearly as practicable, the necessities of the animals for the work required of them, even better results would be obtained, not only in reducing the waste in feed, but in minimizing sickness, and in securing a more perfect physical condition of the animals.

The apparent difficulty in this matter has been largely obviated for the feeder by those, both in Europe and in this country, who have made painstaking investigations, both chemical and physiological, to ascertain the composition and percentage of digestibility of nearly every imaginable kind of feeding material, all of which has been tabulated, and is now within the reach of everybody. With such information at hand, the feeder ought to be able to feed according to his daily price-current list of food stuffs, so to speak. For example: Every horseman knows, or believes ,that good sound oats is a most excellent food for the horse or mule; not simply because it is oats, but because it contains the soluble, digestible nutrients, previously spoken of, in balanced proportion. Or, in other words, it is a perfect food. But, under ordinary circumstances, oats is a very expensive material where large numbers of animals have to be fed, and if we can obtain the same nutritive elements and ration, which oats contain, by selecting and mixing together some less expensive foodstuffs, we are saving money. We are purchasing the protein, carbohydrates and fat through a cheaper source. And, this is, in reality, what a great many are now doing, although, perhaps, not looking at it exactly from this standpoint. Some planters are obtaining a similar amount of these nutritive materials through the medium of a mixture of molasses, corn and cob meal, cotton seed meal, etc., at half the price they formerly paid for the same nutrients when they were buying them through the medium of oats.

I don't know that I have made this point clear to everyone. But what I desire to impress, is, that it is not necessary to have to depend upon any food-stuff; because, should necessity require it, such as a rise in price of one material, rendering it prohibitive, it is possible to get the same nutritive value from a mixture of others by grouping or balancing them to get the required nutritive ratio, which means, the ratio existing between the nitrogenous and the non-nitrogenous nutrients. In fact, I believe the day is shortly coming, when, instead of speaking of buying oats, corn, molasses, cotton seed meal, and so forth; we will talk of purchasing digestible protein, carbohydrates and fat, and merely refer to the former as the sources, or media, through which to obtain these nutrients; just as the agriculturalist now speaks of purchasing his fertilizer, or plant food, through the medium of cotton seed meal for his nitrogen;

acid phosphate for phosphoric acid, and kainit for his potash. The chief simile here is, that the only valuable constituents of an animal food are the soluble nutrients it contains, and which are capable of being absorbed into the circulation to build up the tissues, just as the only valuable parts of the plant food, in the form of commercial fertilizers, are the soluble nutrients—the available nitrogen, phosphoric acid and potash, which are absorbed by the delicate rootlets of the plants, and which go to build up its tissues; the cost of which, in either case, depends upon, or varies with, the cost of the sources from which the nutrients are obtained. Perhaps no better illustration of this could be given than in the case of our molasses and cotton seed meal. In molasses we have the cheapest source, at present, at least, of our digestible carbohydrates; in cotton seed meal, our cheapest source of digestible protein; each being extremely rich in its respective nutrient.

In a careful study of the nutritive value of a food, several things have to be taken into consideration, such as the percentage digestibility of the constituents which enter into it; as it is possible for two foods to contain exactly the same amount of elements, and so, theoretically, be of the same value, but the difference in their digestibility may be such as to render one doubly as nutritious as the other. I have already touched upon the digestible nutrients.

Another point is, the proper proportion of these nutritive elements for the building up of the tissues of the body, and vigorously maintaining the functions of life and the performance of work.

This brings up the subject of "Feeding Standards," which means the grouping of the different digestible nutrients of a food in such quantities as will best nourish the animal under the varied conditions of work; and, with the minimum waste of material.

A ration of food so arranged that its nutritive constituents are grouped together in such a manner, and in proper quantity, to, as nearly as practicable, meet the requirements of the animal, whether it be for maintenance only, or for light, medium or heavy work, is known as a "balanced ration."

Feeding standards are not meant, however, to be rigidly adhered to, as many seem to think, but they have the advantage of supplying the feeder with an excellent guide in computing rations for his animals. In fact, these standards represent a monumental amount of earnest experimentation and work on the part of some of the ablest animal physiologists on both sides of the Atlantic, and have already added greatly to the advancement of scientific agriculture in America, where they were first brought to our attention by Professor Atwater in 1874. But, although a close approximation of them is desirable, it is not expected that they should be followed, in all cases, with mathematical precision.

Perhaps the most universally adopted standards are those known as the Wolff-Lehmann, and are based upon the nutritive requirements per 1,000 pounds of live weight of animal, which in the case of a horse, weighing the above amount, and doing hard work, calls for a day's ration containing 2.5 pounds of digestible protein, 13.8 pounds digestible carbohydrates, and 0.8 pounds of digestible fat; showing a ratio between the protein and the other nutrients, of 1.6; the total dry matter of the food stuffs containing these nutrients is given at 26 pounds. The dry matter, here, refers to the weight of the food after its moisture has been driven off by heat.

Lavalard, a well-known French expert, has a system of feeding on a weight basis; and after experimenting with between 20,000 and 30,000 horses, makes the calculation, that for every 220 pounds of live weight, an animal should receive 2 pounds 14 ounces of oats, and 1 pound 10 ounces of hay. According to this computation of Lavalard's, a heavy draft animal weighing 1,540 pounds, is supposed to require, and should consume, 19 pounds 13½ ounces of oats, and 11 pounds of hay daily.

It will be seen, then, that feeding standards have not been "jumped" at, so to speak, but have been reached after a large amount of earnest effort, and based upon careful and systematic observation, experiment and reasoning, and are of immense value to the feeder of large numbers of work animals, provided he avails himself of them.

From the wide difference in the amounts of molasses fed per head and per diem, it is a question whether or not some planters are not wasting some of this valuable food nutrient. True, its digestibility is represented by about 100; and it is cheap. But an excessive amount in the ration may not only not be absorbed, but interfere with the more perfect digestion of the other nutrients; and it is worth while to remember, that even at 3 cents per gallon, which I believe is below the current price, the small amount of 2 pounds per day, more than is necessary for the animal, represents, on a plantation with a hundred mules, the sum of $186 in the course of a year; or, in other words, the cost of a fairly respectable mule.

Of course, it is not within my province to enter a complaint against unnecessary expenditure upon the plantation; that rests entirely with the planter himself. But I feel that I would be recreant to duty and ungrateful of the compliment of being invited to appear before this Association this evening, did I fail to refer to the apparently insignificant wastes which, in the aggregate, assume such considerable proportions.

As to the important question of how best to feed molasses, I think I had better leave that to be brought out in discussion by those present who have tried the various methods, and can, therefore, speak from actual experience. I will say, however, that it is unsatisfactory to feed it mixed with whole grains, as the tendency is for the animal to swallow the grains, in the whole state, along with the molasses, and they pass through the digestive tract unacted upon and are, therefore, wasted to a very large extent.

Again, unless the stipulated quantity of molasses is either given by itself, or mixed with the other ingredients of the ration which are in a state of fine division, such as ground grains or meal, it is impossible to know just how much the animal consumes; and when a ration is balanced, it is meant that all of it should be eaten. If, when allowed carte blanche by the open trough system, for example, the mule eats an excessive quantity, it is a waste of material, besides the probability of upsetting the balance of nutrients in the ration. On the other hand, should he eat less than the desired quantity, the balance is upset the other way, and he is not receiving his requisite amount.

Here, again, I am trespassing upon the prerogative of the planter, as the question of waste or economy rests altogether with himself. But I simply give expression to such observations for his consideration. I will repeat, however, in order to impress the fact, which should be borne in mind, that a work animal is under abnormal conditions, eating often ravenously when food is placed before him, but which, in his natural state, would be partaken of in small quantities and often, or as his inclination dictated. Consequently, as I have previously stated, his dietary for best results should be directed by the higher intelligence of his master, or whoever has supervision over him.

Another point which I consider of great importance. All of the best authorities recommend, and practice teaches, that animals performing fast or laborious work should, at that time, have the bulky or roughage portion of their ration reduced, and the concentrates somewhat increased; and, that the greater portion of the roughage should be fed after the day's hard work is over. The reason for this is obvious! Bulky food, besides producing a condition of engorgement, requires a much longer time for preparation before it is in a fit state for stomach and intestinal digestion, and it frequently happens, during the hard-working season, that the necessary time can not be given the animal to complete thorough mastication and indigestion before he has to turn out to perform some laborious work. When at rest in the stable, feeding, there is a considerable determination of blood to the digestive organs to provide the various ferments and fluids. But, when the animal is put to hard work, with a digestive system engorged with half-masticated, half-digested food, of a coarse bulky nature, there is placed a considerable check upon the process of digestion; because a large quantity of blood is diverted from the digestive organs to the muscular system to give nourishment to it, and to supply the waste occasioned by the oxidation of muscular tissue, resulting from the increased activity of these organs—the muscles. This is not, perhaps, realized by everyone who feeds work animals. But we all know, or at least can appreciate the fact, that increased activity in any part, or organ, of a living animal, requires an increased blood-supply. If anything should occur to interfere with this blood-supply, function is sure to be deranged; and this is what happens, under the conditions just alluded to, in connection with digestion.

I think there can be little doubt that molasses feeding has obviated this condition, however, to a large extent, on account of the ease with which the chief nutrient—sugar—passes almost directly into the circulation.

It is not only necessary, then, that a work animal, be supplied with the necessary amount of food per day, and that food properly balanced, but there should be a system in feeding, based upon the anatomical arrangement of its digestive organs, and, as nearly as practicable, upon its natural method of feeding, which is small-quantities at a time, and often. This would point to the necessity of having the day's ration divided into at least three feeds; giving a smaller third, which should be mainly concentrates, in the morning and at noon, before the animal goes to work, and the larger third, with the greater part of the bulky food, at night, when there is more time for mastication and digestion. The twice-a-day system, although the amount may represent the requisite daily quantity, favors engorgement and imperfect digestion, and is not in keeping with the animal's natural method of feeding. And, in addition to this, more benefit is derived from the ration when divided into three diets, than when given at twice, because of the excessive quantity at one time, and the tendency to "bolt" a considerable portion of it at the beginning, without the necessary chewing. And, still further, a work animal that has to stand up the greater part of the night in order to satisfy its appetite, is deprived of a great deal of rest which its muscular system needs to fit it for work the following day.

As to the quantity of molasses fed, I have previously mentioned that the average, on 42 places, is about 9.5 pounds. I should say that the majority use in the neighborhood of from 8 to 12 pounds per head per diem; one planter feeding as low as 2 pounds and another as high as a fraction over 21 pounds. The quantity should, of course, depend upon the carbohydrate constituents contained in the other materials fed. Being the cheapest source from which to obtain this nutrient, however, and being in such easily digestible form, it would seem economy to supply the sugar-constituent of the food chiefly through molasses. But, there is not any economy in giving an over-supply simply because it is cheap, and the animal will eat it. Wolff, the great German, to whom we are so much indebted for *information on animal nutrition*, states that the addition of starch or sugar to a diet of hay or straw, if it exceeds 10 per cent. of the dry fodder, decreases its digestibility, particularly of the albuminoids (protein). Hence, we are shown the necessity for foods being properly balanced in their digestible nutrients, to prevent the depressing effect of a large amount of carbohydrates on the digestion of protein—the nitrogenous element of the food.

In conclusion, I will say that my remarks concerning molasses have been confined entirely to the raw material available upon the plantation, and not to any of the commercial feed stuffs of which it may form an ingrdient.

Gentlemen, in our low-grade sugar house molasses, the Louisiana sugar planter has, indeed, struck a veritable "gold mine," as a feeding material; not altogether because of its cheapness, but its almost perfect digestibility in the raw state, which accounts largely, in my own opinion, for the great success, in different ways, which has followed its use. Let us not abuse it, however, but use it in such a manner as to be able to obtain the maximum of results from it.

Sir William Ramsey, the great British scientist, recently remarked: "All our progress since the time of Sir Isaac Newton has not falsified the saying of that great man—that we are only children, picking up here and there a pebble from the shore of knowledge, while a whole unknown ocean stretches before our eyes. Nothing can be more certain than that we are just beginning to learn something of the world in which we live, and move, and have our being."

I think, however, that with regard to the intelligent feeding of the sugar plantation mule, we are, at least, beginning to divest ourselves of our "swaddling clothes." Are we all prepared to take advantage of, and benefit by, the progress that has been made? That is the question!